

(3) a cell plate electrode including a second tantalum nitride film formed on and contacting an upper surface of said tantalum oxide film and a copper film formed on and contacting an upper surface of said second tantalum nitride film.

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REMARKS

At the time of the final Office Action dated December 18, 2001, claims 1-6 were pending in this application. Of those claims, claims 1-5 have been rejected. Applicants acknowledge, with appreciation, the Examiner's indication that claim 6 contains allowable subject matter.

By this amendment, claim 2 has been amended, and care has been exercised to avoid the introduction of new matter. Specifically, claim 2 has been amended to clarify the claim by differentiating between first and second tantalum nitride films. Applicants submit that the present Amendment does not generate any new issue. The Examiner already differentiated between first and second tantalum nitride films in the statement of the rejection. As such, the amendment to claim 2 does not present any new issue for the Examiner to consider.

On page two of the Office Action, the Examiner objected to the Specification. In particular, the Examiner states that the "well-known value" of the work function for TaN is 2.17 eV, whereas the values of the work functions for TaN<sub>x</sub> stated in the specification are 5.41 eV and 5.95 eV. As such, the Examiner asserts that the value of x in TaN<sub>x</sub> must significantly deviate from 1.

Under the first paragraph of 35 U.S.C. § 112, the patentee must disclose in the patent sufficient information to put the public in possession of the invention and to enable those skilled in the art to make and use the invention. On page eleven of the specification, Applicants have defined a material having a work function that is greater than the work function of 4.95 eV for a



titanium nitride film, and on page ten of the specification, Applicants have indicated that a  $TaN_x$  film has such a property. As alluded to the Examiner, Applicants have not specifically stated what the value of "x" can be. However, Applicants respectfully submit that the disclosure of a particular work function for  $TaN_x$  is sufficient for one having ordinary skill in the art to determine the value of "x" in  $TaN_x$ . As supported by the discussion in U.S. Patent No. 6,130,123 to Liang, et al. (a portion of which was reproduced in the Amendment filed November 29, 2001), a reported value for the work function of  $TaN_x$  is 5.41. Thus, the value of "x" is likely to be known by Liang, et al. As Applicants are only required to disclose sufficient information (and not complete information) to put the public in possession of the invention, Applicants respectfully submit that this requirement has been met. As such, Applicants respectfully request that the Examiner withdraw the objection as to the specification.

**Claim 1 is rejected under 35 U.S.C. § 103 for obviousness predicated upon Alers, et al., U.S. Patent No. 6,265,260 B1 (hereinafter Alers 1), in view of a publication to Drynan, et al. (hereinafter Drynan)**

On page five of the Office Action, the Examiner concluded that the combined disclosures of Alers 1 and Drynan generated the invention as claimed. This rejection is respectfully traversed.

Applicants respectfully submit that that Examiner has failed to consider the invention as a whole. Claim 1 recites, in part, a contact plug that includes a tungsten film, and a storage electrode that includes a tantalum nitride film. Claim 1, however, also recites that the "tantalum nitride film formed on and contacting an upper surface of said tungsten film." As such, the claimed invention, as a whole, requires that the tantalum nitride film and the tungsten film be in contact.

The Examiner has stated that Alers 1 teaches a storage electrode that includes a tantalum nitride film. The Examiner has also stated that Drynan teaches using tungsten as a plug material.

The Examiner's stated motivation for combining these references is that:

the purpose of the use of tungsten as a preferred material for a/o plugs as stated by Drynan for its low resistance (see abstract) in capacitor interconnect structures carries over immediately to the invention of the plug in the capacitor structure by Alers et al.

The Examiner, however, glossed over the recited limitation that a tantalum nitride film be formed on the tungsten film by stating:

Low resistance combined with high-temperature resilience (refractory property) is a well-known advantage for capacitor metal, largely explaining the popularity of tungsten in this art, irregardless whether the capacitor plug material is in contact with a tantalum nitride film as claimed by Applicant or not. (emphasis added)

The Examiner's recited motivation to combine Alers 1 with Drynan, however, is illusory. The Examiner has asserted that there are positive properties associated with using tungsten for a plug (or, in fact, for almost any other conducting feature in a semiconductor device), and it is the benefit obtained from these properties that the Examiner argues provides sufficient motivation to modify Alers 1 with Drynan. However, any material that can be used as a plug in a semiconductor device has advantageous properties. Furthermore, while using the type of analysis applied by the Examiner, any combination of materials in a standard structure (such as a capacitor) is obvious because each and every material that could be used in the structure has some benefit, and this benefit can be used as a basis for a motivation to combine the materials. However, this type of analysis ignores whether the claimed invention as a whole is obvious over the applied prior art. In analyzing whether the claimed invention as a whole, the Examiner cannot consider the invention as only a collection of claimed parts (or features). Rather, an "invention as a whole" analysis also requires the Examiner to consider the claimed interactions between the claimed parts (or features).

The claimed invention requires that a tantalum nitride film be formed on the tungsten film, and it is legally erroneous to ignore any claim limitation. **Uniroyal, Inc. v. Rudkin-Wiley Corp.**, 837 F.2d 1044, 5 USPQ2d 1434 (Fed. Cir. 1988). However, neither Alers 1 nor Drynan, alone or in combination, suggest forming a tantalum nitride film over a tungsten film. The only motivation for such a limitation is Applicants' own disclosure. Applicants' disclosure, however, is forbidden territory for the Examiner to obtain the requisite motivation for combining the applied prior art. **Panduit Corp. v. Dennison Mfg. Co.**, 774 F.2d 1082, 227 USPQ 337 (Fed. Cir. 1985).

The Examiner has also stated that the combination of Alers 1 and Drynan is obvious, in part, because the claim has failed to identify the criticality of the work functions. In this regard, Applicants need only recite those features in the claims that distinguish the claimed invention from the applied prior art. As such, the claims need not identify each and every feature of the invention.

In the Amendment filed on November 29, 2001, Applicants identified indicia of non-obviousness that would undermine any obviousness conclusion. However, the present Office Action has failed to address whether these indicia of non-obviousness have been considered by the Examiner. For example, the Examiner is referred to first three full paragraphs on page three of the specification, reproduced below.

In such a structure, the storage electrode and the cell plate electrode are formed of tantalum nitride film, the work function of which is greater than that of the titanium nitride film used to form the cell plate electrode of the capacitor in the conventional semiconductor device. This restricts introduction of electrons into the tantalum oxide film forming the capacitor dielectric film. Thus, it is possible to suppress generation of a leakage current in the capacitor dielectric film.

Further, the contact plug is formed using the tungsten film. Therefore, it is possible to prevent oxidation of the upper surface of the contact plug, which would be inevitable during a manufacturing process when a polysilicon film is used to form the storage electrode as in the case of the conventional semiconductor device. This prevents formation of additional capacitance because of the oxidation of the upper surface of the contact plug. As a result, reduction of capacitance of the capacitor is suppressed.

Moreover, the tantalum nitride film offering an effective barrier is formed on the tungsten film. Thus, counter diffusion between the tungsten film and the tantalum nitride film is prevented. This restricts generation of a leakage current in the capacitor dielectric film due to the counter diffusion between the

contact plug and the storage electrode. As a result, the charge retaining capability of the capacitor is improved.

Alers 1 discloses, as shown in Fig. 1, a capacitor formed of a cell plate electrode (TaN) 34, capacitor dielectric film ( $\text{Ta}_2\text{O}_5$ ) 33, and storage electrode (TaN) 30. However, Alers 1 fails to disclose that the contact plugs 26 connected to the storage electrode (TaN) 30 includes tungsten (W). Drynan discloses the contact plug being made of tungsten (W), and this contact plug (in connection with another tungsten layer) is used to reduce sheet resistance. However, Drynan fails to disclose that the tungsten plug is used to "prevent oxidation of the upper surface of the contact plug," which is one of the objects of the invention recited in claim 1 (page 3, lines 9-16 of specification). The claimed structure of claim 1, therefore, produces unexpected benefits that are not suggested or recognized by the applied prior art. These unexpected benefits constitute indicia on nonobviousness that must be considered in light of any obviousness conclusion.

It should, therefore, be apparent that the Examiner has not discharged the initial burden of establishing a prima facie case of obviousness under 35 U.S.C. § 103. Moreover, upon giving due consideration to the nonobviousness indicia of record stemming from the unexpected benefits provided by the present invention, the conclusion appears inescapable that one having ordinary skill in the art would not have found the claimed invention as a whole obvious within the meaning of 35 U.S.C. § 103. **In re Piasecki**, 745 F.2d 1468, 223 USPQ 785 (Fed. Cir. 1984); **Jones v. Hardy**, 727 F.2d 1524, 220 USPQ 1021 (Fed. Cir. 1984). Applicants, therefore, respectfully submit that the imposed rejection of claim 1 under 35 U.S.C. § 103 for obviousness predicated upon Alers 1 in view of Drynan is not factually or legally viable and, hence, solicit withdrawal thereof.

**Claim 2 is rejected under 35 U.S.C. § 103 for obviousness predicated upon Alers 1 in view of Alers, U.S. Patent No. 6,271,596 B1 (hereinafter Alers 2)**

On pages four and five of the Office Action, the Examiner asserted that Alers 1 teaches all of the claimed limitations except a copper film formed on an upper surface of a tantalum nitride film, which is taught by Alers 2. This rejection is respectfully traversed.

The Examiner stated, with regard to Alers 2, the following:

the tantalum nitride layer or film 303 serves as top capacitor plate (column 5, lines 15-18), or cell plate electrode as it is called in Alers 1, while a metal layer of film (numeral 308 in Alers 2) is formed on and contacts the upper surface of aforementioned tantalum nitride layer or film (numeral 303 in Alers 2). As possible material for the aforementioned metal layer or film Alers 2 mentions copper (column 4, lines 37-40)

Applicants respectfully submit that the Examiner's assertion in the underlined portion of the above excerpt is false. Alers 2 does not mention that copper can be used for to fill the cavity 308. Although the Examiner uses reference numeral 308 as describing a metal layer, reference numeral 308 is in fact used to describe a cavity (column 3, line 33, 60-61). Also, column 4, lines 37-40 of Alers 2 states that:

As shown in Fig. 8, the window 706 is thereafter back-filled by standard technique with a layer of conductive material 801, such as tungsten or copper.

As shown in the subsequent Figures 9-10, the layer of conductive material 801 is planarized and etched to form feature 300. As stated in column 4, lines 8-10, "[t]he surfaces of the cavity 308 and surface 300 form the lower plate of the capacitor." As such, contrary to the Examiner's assertion, copper is not mentioned as a material to fill the cavity 308. Instead, copper is suggested as a possible material for the lower electrode.

Claim 2 recites "a copper film formed on and contacting an upper surface of said second tantalum nitride film." However, Applicants also note that neither Alers 1 nor Alers 2 teach or

suggest the formation of a copper film on a tantalum nitride film. Alers 1 makes no mention of copper, and the copper film 303 of Alers 2 only contacts a metal interconnect 304 and a tantalum oxide dielectric 302. Applicants also incorporate herein the invention "as a whole" argument previously presented with regard to claim 1. The Examiner has failed to establish the invention as a whole is obvious by failing to consider the claimed limitation of a copper film contacting an upper surface of a second tantalum nitride film.

Applicants further note that one object of the invention recited in claim 2 is to prevent a leakage current due to punch-through of electrons to a capacitor dielectric film ( $\text{Ta}_2\text{O}_5$ ) that occurs because the copper film is used for the cell plate electrode in which electrons move at high speed (page 3, line 31 to page 4, line 10 of the specification). This object cannot be disclosed by either Alers 1 or Alers 2 because neither recites a copper film in contact with a  $\text{Ta}_2\text{O}_5$  film that acts as a barrier film to prevent punch-through of copper electrons into the capacitor dielectric film.

For the reasons stated above, Applicants, therefore, respectfully submit that the imposed rejection of claim 2 under 35 U.S.C. § 103 for obviousness predicated upon Alers 1 in view of Alers 2 is not factually or legally viable and, hence, solicit withdrawal thereof.

**Claims 3-5 are rejected under 35 U.S.C. § 103 for obviousness predicated upon Alers 1 in view of Nishioka et al., U.S. Patent No. 5,811,851 (hereinafter Nishioka)**

On pages six through eight of the Office Action, the Examiner concluded that the combination of Alers 1 in view of Nishioka disclosed the invention as claimed. This rejection is respectfully traversed.

Claim 3, in part, recites the following:

a contact plug including tungsten,

a first indium oxide film (as a storage electrode) formed on the contact plug,

a tantalum oxide film (as a dielectric layer) formed on the first indium oxide film,

a second indium oxide film (as a cell plate electrode) formed on the tantalum oxide film.

The Examiner stated that Alers 1 discloses a basic capacitor structure (plug, storage electrode, dielectric layer, and cell plate electrode) with the dielectric layer including tantalum oxide film. The Examiner then used the extremely broad disclosure of Nishioka to teach that the storage electrode and cell plate electrode are both formed from indium oxide films and that the contact plug includes tungsten. As part of statement of the rejection, the motivation established by the Examiner to modify Alers 1 in view of Nishioka is "to proscribe storage and cell plate electrodes to include an indium oxide film and to proscribe the contact plug to include tungsten."

Applicants note that the requisite motivation to support the ultimate legal conclusion of obviousness under 35 U.S.C. § 103 is not an abstract concept, but must stem from the applied prior art as a whole and have realistically impelled one having ordinary skill in the art to combine specific references to arrive at a specifically claimed invention. **In re Deuel**, 51 F.3d 1552, 34 USPQ2d 1210 (Fed. Cir. 1995); **In re Newell**, 891 F.2d 899, 13 USPQ2d 1248 (Fed. Cir. 1989). The mere identification of claim features in disparate references does not establish the requisite realistic motivation to support the ultimate legal conclusion of obviousness under 35 U.S.C. § 103. **Grain Processing Corp. v. American-Maize Products Co.**, 840 F.2d 902, 5 USPQ2d 1788 (Fed. Cir. 1988). Moreover, a generalization does not establish the requisite motivation to modify a specific reference in a specific manner to arrive at a specifically claimed invention. **In re Deuel**, supra. Rather, a burden is imposed upon the Examiner to identify a source in the applied prior art for



each claim limitations and identify a source for the requisite realistic motivation to modify a particular reference in a particular manner to arrive at a specifically claimed invention. **Smiths Industries Medical System v. Vital Signs Inc.**, 183 F.3d 1347, 51 USPQ2d 1415 (Fed. Cir. 1999); **In re Mayne**, 104 F.3d 1339, 41 USPQ2d 1451 (Fed. Cir. 1997).

Unlike the previous rejections, in which the Examiner at least provided some modicum (albeit illusory) of a motivation to combine the applied references, the Examiner has failed to establish any realistic motivation whatsoever to combine Alers 1 with Nishioka. The number of possible combinations of materials disclosed by Nishioka for the contact plug, storage plate electrode, and cell plate electrode likely numbers in the tens of thousands if not greater. However, without any stated reasons why, the Examiner has plucked the combination of materials recited in claim 3 out of the thousands of possible combinations disclosed by Nishioka and stated that this combination of materials recited in claim 3 is obvious in view of the combination of Alers 1 and Nishioka.

Applicants incorporate herein the invention "as a whole" argument previously presented with regard to claim 1. The Examiner has failed to establish the invention as a whole is obvious by failing to consider the claimed limitations of a tantalum oxide film being contacted by two separate indium oxide films. In analyzing whether the claimed invention as a whole, the Examiner cannot consider the invention as only a collection of layers having different materials. Rather, an "invention as a whole" analysis also requires the Examiner to consider the claimed interactions between the layers of different materials. For the reasons stated above, Applicants, therefore, respectfully submit that the imposed rejection of claim 3 under 35 U.S.C. § 103 for obviousness predicated upon Alers 1 in view of Nishioka is not factually or legally viable and, hence, solicit withdrawal thereof.

With regard to claims 4 and 5, which are dependent upon claim 3, Applicants incorporate herein the arguments previously presented with regard to claim 3. As such, claims 4 and 5 are also patentable over the applied prior art at least on the basis of their dependency on claim 3.

Attached hereto is a marked-up version of the changes made to the claims by the current amendment. The attached page is captioned "Version with markings to show changes made."


Applicants have made every effort to present claims which distinguish over the prior art, and it is believed that all claims are in condition for allowance. However, Applicants invite the Examiner to call the undersigned if it is believed that a telephonic interview would expedite the prosecution of the application to an allowance. Accordingly, and in view of the foregoing remarks, Applicants hereby respectfully request reconsideration and prompt allowance of the pending claims.

To the extent necessary, a petition for an extension of time under 37 C.F.R. § 1.136 is hereby made. Please charge any shortage in fees due in connection with the filing of this paper, including extension of time fees, to Deposit Account 500417, and please credit any excess fees to such deposit account.

Respectfully submitted,

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Version with markings to show changes made

IN THE CLAIMS:

Please amend claim 2 as follows:

2. (Twice Amended) A semiconductor device, comprising:
  - a storage electrode including a first tantalum nitride film formed over a semiconductor substrate;
  - a capacitor dielectric film including a tantalum oxide film formed on and contacting an upper surface of said first tantalum nitride film; and
  - a cell plate electrode including a second tantalum nitride film formed on and contacting an upper surface of said tantalum oxide film and a copper film formed on and contacting an upper surface of said second tantalum nitride film.